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Phytoremediation of Peconic River Sediments

Peconic River Remedial Alternatives Workshop
Brookhaven National Laboratory

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Company Highlights

- Edenspace is a systems technology company that uses living plants in innovative products and services to restore and enrich our surroundings.
- Founded in 1998, Edenspace is headquartered in Reston, Virginia, with 14,000 ft^2 of new office, laboratory, and growth chamber space under construction.
- Edenspace acquired Phytotech's phytoremediation business in June 1999, thereby becoming the world leader in the use of plants to extract minerals from soil and water, including lead, uranium, arsenic, and radionuclides
- As a result of its own research and agreements with Rutgers University, University of Florida, and the University of Washington, Edenspace now owns or has exclusive license to 12 patents in the areas of phytoremediation, phytoextraction, and rhizofiltration.

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Technology Applications

- **Industrial Soil Lead** *In-Situ* RCRA Corrective Action, combines phytoextraction with phytostabilization.
- **Residential Soil Lead** Residential phytoextraction using turfgrass.
- **Firing Range Lead** *Ex-situ* phytoextraction of small arms firing range soils.
- **Sediment Treatment Research** Heavy metal phytoextraction of dewatered sediments.
- **Phytofiltration** Arsenic removal from power industry wastewater.
- **Phytoextraction of Strategic Metals** Tungsten and molybdenum biomining.

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Types of Phytoextraction

- **Induced Uptake**
  - **Rapid, short-term uptake using high biomass crop plants (e.g., *Brassica juncea,* sunflower, etc.).**
  - **Foliar and soil amendments used to enhance contaminant availability and plant uptake.**
- **Natural Hyperaccumulation**
  - **Uses the natural high affinity for uptake of metals by specific plant species (e.g., Edenfern for As).**
  - **Assessed and developed according to site specific conditions.**
- **Passive Phytoextraction**
  - **Moderately elevated rates of uptake with minimal amendment input (e.g., turfgrass remediation of residential soils).**
  - **Long term remediation time frames, non-hazardous biomass production.**
  - **Cyclic harvest and removal of biomass.**

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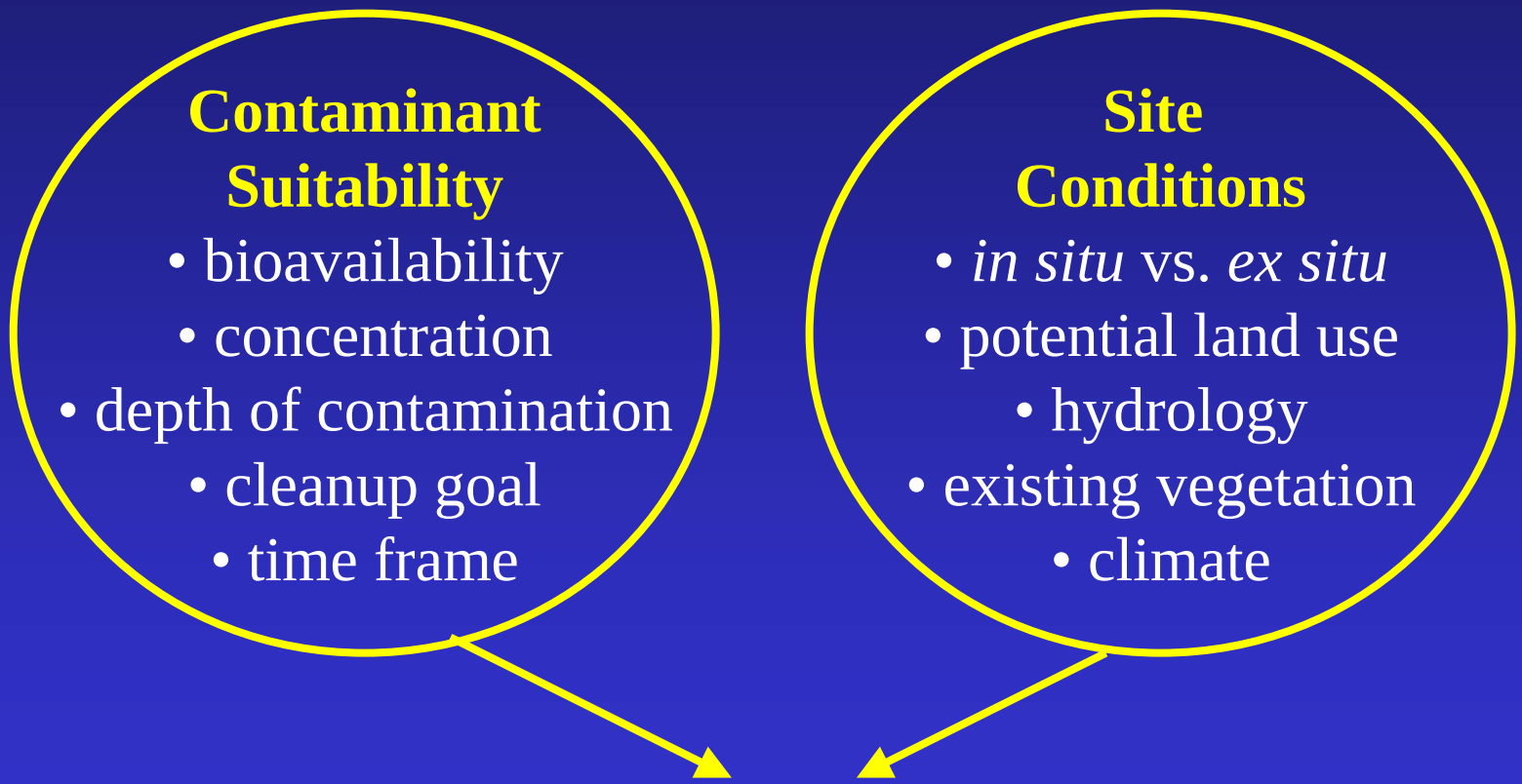
Phytoextraction Decision Criteria



Induced Uptake **Natural Hyperaccumulation** **Passive Phytoextraction**

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Process Overview

- **Site applicability/treatability analysis**
  - Soil chemical and physical analysis
  - Phytometric parameters
    - Contaminant availability/chemical fractionation
    - Ecological considerations
  - Soil suitability for plant growth and metal uptake
- **Sampling plan - determine baseline concentrations**
- **Develop agronomic/phytometric procedures**
- **Implementation**
- **Progress assessment and monitoring**
- **Site restoration**

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Critical Parameters for Success

- Establishing soil concentrations and project goals
- Soil fertility and plant growth (root development and biomass production)
- Metal availability for plant uptake
- Climate and site conditions

Challenges

- **Recalcitrant contaminants, particulate contamination**
  - Physical treatment/particle size separation to remove particulates followed by phytoextraction to remove remaining plant available contaminants
  - Phytostabilization to minimize runoff and leaching of contaminants
- **Contaminants below the root zone**
  - Excavation followed by *ex situ* phytoremediation treatment
- **Unfavorably high contaminant concentrations**
  - Identification and segregation of concentration zones followed by phytoextraction of suitable areas combined with excavation of less favorable areas
- **Unfavorable groundwater or undesirable leaching conditions**
  - *Ex situ* treatment
  - Liner and water management, root growth metrics

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Unique Challenges of the Peconic River Contamination

- **Multiple contaminants (organic and inorganic)**
  - Requires multi-faceted approach to facilitate organic degradation and metal removal.
  - Removal rates will vary for each contaminant.
  - Integration of multiple plant species
- **Distribution of contaminants**
  - Large non-contiguous areas of low level contamination
  - Submerged sediments (reducing conditions)
- **Fragile, sensitive ecosystem**
  - Minimize disruption and downstream migration of contaminants.
- **Existing vegetation**
  - Heavy native vegetation may not be suitable for phytoremediation.

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Case Study - Simsbury, CT

Site Conditions

- Surface soil lead
- Groundwater concerns
- Address leachable lead as well as total lead concentrations
- On-going site use and activities

Approach

- Identify soil areas exceeding 1000 mg/kg total lead
  - Use phytoextraction to decrease total soil lead followed by phytostabilization to remove soluble and leachable (SPLP) lead
- Remaining areas receive phytostabilization to remove bioavailable lead

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Summary of Results - Simsbury

- Areas exceeding total lead concentration goals were reduced.
- Average lead concentrations from all crops of *Brassica juncea* exceeded 1000 mg/kg.
- SPLP leachable lead decreased from an average of 0.85 mg/l in April 1998 to 0.08 mg/l in October 1999.
- No elevated levels of lead detected in shallow groundwater, during the three-year project

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Case Study - DaimlerChrysler

Site Conditions

- Initial Lead Concentrations Ranged From 75 to 3,490 Mg/kg.
- Elevated Lead Concentrations Below the Root Zone
- One Year Clean-up Target

Approach

- Excavate 4360 CY of Lead Contaminated Soil for Placement in 65,000 Square-Foot *Ex-Situ* Phytoremediation Treatment Cell.
- Soil Placed in 19 to 24-Inch Thick Lift and Treated Using Sunflower Followed by Indian Mustard.
- Dispose of Soil Exceeding Total Lead Regulatory Goal of 900 mg/kg at the Conclusion of One Season

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Summary of Results - DaimlerChrysler

- Achieved the regulatory goal for soil lead concentration of 900 mg/kg in one growing season.
- Soil was replaced in original location
- DaimlerChrysler presented a 1999 environmental excellence award to the Detroit Forge phytoremediation project team for the team's innovative use of phytoremediation that saved DaimlerChrysler more than $1,000,000 compared to alternative remediation techniques

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Phytoremediation of Peconic River Sediments

- Requires an innovative approach to simultaneously address inorganic and organic contaminants.
- Effective water management will be a key parameter to success.
- Adaptation of existing vegetation for phytoremediation purposes.
- Integration of conventional techniques where appropriate to maintain the ecosystem and reduce the potential contamination risks.